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NOTE BY THE SECRETARY-GENERAL

The Secretary-General has the honour to transmit to the members of the Security Council the attached communication which he has received from the Director-General of the International Atomic Energy Agency (IAEA).

## Annex

## Letter dated 27 August 1991 from the Director-General of the International Atomic Energy Agency addressed to the Secretary-General

Please find attached the report of the fourth IAEA inspection in Iraq under Security Council resolution 687 (1991). You may deem it appropriate to transmit the report to the members of the Security Council. I remain, of course, available with the Chief Inspector, Mr. David Kay, for any consultations you or the Council may wish to have.

(Signed) Hans BLIX

Enclosure

**REPORT ON THE FOURTH IAEA ON-SITE INSPECTION IN IRAQ UNDER SECURITY COUNCIL RESOLUTION 687 (1991)**

**27 July-10 August 1991**

**Salient Points**

- The team was given full access to all designated sites, and the attitude of the Iraqi side continued to be as co-operative as in the course of the third inspection. Reticence was, however, noted as regards the disclosure of the procurement sources of equipment and material relevant to the centrifuge enrichment project. Deceptive behaviour was admitted in at least one instance in the course of the third inspection.

- Extensive information in response to intense questioning was gathered, and a large number of documents in the form of reports, detailed fabrication drawings and computer printout records of laboratory experiments were brought to Vienna for further analysis.

- On the first inspection day the Iraqi representative handed over to the team a list of nuclear materials which included items not previously declared. It confirmed the existence of a clandestine programme to i) manufacture several kilograms of uranium oxide fuel, ii) irradiate it in the IRT-5000 reactor and iii) reprocess the irradiated fuel in order to chemically separate gram amounts of plutonium.

- It is now certain that the Electro-Magnetic Isotope Separation (EMIS) approach to uranium enrichment was given priority and that the relevant project was fast-paced and had achieved the stage of initial industrial production at the Tarmiya establishment. The visit to several heavy mechanical production facilities used for the local fabrication of EMIS components indicated that their likely production rates were consistent with the Iraqi-stated amounts of EMIS equipment produced before the production facilities had been bombed. The production of uranium tetrachloride (EMIS feed material) would have been more or less sufficient to cover the needs of Tarmiya once the latter had reached full operation at the design capacity. The plan for Tarmiya was to bring on line a production facility of 90 separators which, with an average availability of 55%, could have produced 15 kg of highly enriched uranium (HEU) per annum using natural uranium as feed. An increase in separator availability, as a consequence of improvements in the systems, with a corresponding increase in the annual production of HEU, was deemed possible by the Iraqis.

- Iraq supplied the third inspection team with limited information on the magnitude of their centrifuge enrichment programme. A priority task of the fourth team was to obtain a more comprehensive picture of the Iraqi efforts in this area, including details of the overall plan and direction of the programme. The team was provided with an overall project plan showing key dates. According to this plan, following mechanical and functional trials on different models (1987-1991) a facility for centrifuge production would have started operation at the end of 1991. A 100-machine cascade would have been in operation in 1993 and a 500-machine cascade would have gone on stream in 1996. The team was able to visit the production facility of the Al Furat Project (the code name of this programme) at a site close to An Walid, 20 km south of Baghdad, a complex consisting of four buildings, two of them new. This complex had not suffered any attacks during the war, nor was it previously known as a nuclear-related site.

Although machine tools for manufacturing the centrifuges had not yet been installed (they had been procured but were dispersed to protect them against possible air attacks around the 25 July 1991 deadline), from the dimensions of this centrifuge production facility the team concluded that, once in full operation, the facility could easily have turned out 600 centrifuges per annum with the equipment already procured for this site.

- Extensive inspection work was carried out at the Al Jesira chemical production facility in the Mosul area, first designated by the Special Commission during the third inspection. This facility, which was heavily damaged by the bombing and by the salvaging-deception activities undertaken afterwards, housed the $UO_2$ and $UCl_4$ production lines and was the intended site for the production of $UF_6$ to feed the centrifuge enrichment project.

- No conclusive evidence was obtained as to the existence of weaponization activities.

**Introduction**

1. This report summarizes findings of the fourth inspection carried out by the IAEA under the terms of Security Council Resolution 687 (1991) with the assistance and co-operation of the Special Commission of the United Nations. The team consisted of 14 inspectors and 6 supporting staff, comprising 11 nationalities. It was headed by Mr. David Kay of the IAEA as Chief Inspector. The team arrived in Iraq on 27 July and started on-site activities on 28 July. The inspection ended on 10 August 1991, when the team departed for Bahrain. A total of 22 sites were inspected, 14 being visited for the first time - five of these 14 new sites were designated by the Special Commission.

2. In addition to follow-up activities arising from information gathered in the course of the third mission and to inspection of the new sites designated by the Special Commission, the following tasks were assigned to the fourth team:

   - Electro-Magnetic Isotope separation (EMIS) programme: to make a detailed assessment of the programme as a whole and an analysis of the capacity of local industries to produce process equipment, components and feed material;

   - Centrifuge enrichment programme: to obtain a more comprehensive picture of the programme, particularly with regard to machine component manufacturing, system (cascade) design and $UF_6$ feed preparation;

   - Weaponization activities: to verify the existence of activities relevant to the research and development, manufacturing and testing required in order to convert fissile material into a nuclear weapon.

3. In the morning of the first inspection day (28 July), the Iraqi representative submitted to the team a letter dated 27 July containing a list of nuclear material which included items not previously declared. The inspection programme had accordingly to be modified, in order to accommodate additional verifications.

4. No access problems were faced during the fourth inspection, and the attitude of the Iraqi representatives continued to be one of co-operation. As expected, the process of additional clarification and subsequent verification through detailed questioning by the team continued. The team's requests for information on procurement sources of specialized equipment were not met. A large number of samples were taken and a huge amount of documents and drawings obtained; their evaluation will require considerable time.

5. It became evident to the team that only high-level officials such as Dr. Jaffar are empowered to release information on sensitive matters. The same questions asked of other senior Iraqi officials produce untruthful answers. As this is greatly hindering the inspection process, complete frankness should be demanded - in the interest of both sides.

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**The Electro-Magnetic Isotope Separation (EMIS) Project**

6. The mission of the team's EMIS experts was to provide as comprehensive a description as possible of the EMIS project and to assess the capability and product of that project.

Project Planning and Design

7. As clarified during the third inspection, the EMIS project was originated and directed by Dr. J.D. Jaffar. Dr. Jaffar is currently Vice-Chairman of the Iraqi Atomic Energy Commission (IAEC) and Deputy Minister of Industry and Minerals (MOI). In addition to the EMIS project, Dr. Jaffar now appears to have been in charge of the overall enrichment effort.

In several meetings with team members, Dr. Jaffar and others reiterated the principal reason for the project - i.e. the desire to create a domestic enrichment and nuclear fuel program, with consequent stimulation of a broad development of Iraq's industrial infrastructure. Dr. Jaffar claimed that the programme would eventually have been declared openly. There were persistent denials that the program had any weapons goal. However, Dr. Jaffar appeared to be aware of the implausibility of the denials (on several occasions openly prefacing his own remarks with the acknowledgement that the potential for making weapons material was obvious), but consistently refused to acknowledge that a weapons development intent had been central to the origin of the project.

It is now certain, however, that the EMIS project was fast-paced and that all of its components were of an industrial scale, which would have resulted in significant production of weapons-grade material.

The IAEC carried out necessary development work in physics and chemistry at its own sites. It enhanced the indigenous capabilities of Ministry of Industry (MOI) establishments for fabricating process components and, as necessary, provided design criteria - and awarded contracts - to foreign contractors for civil construction and non-process-specific components. As far as possible, the contracting process was used to upgrade local civil engineering practices as well.

According to MOI manufacturers, customers - principally the IAEC - supplied raw materials, special tooling, and design and production drawings and took back all drawings, acceptance reports and rejected items along with the accepted finished products. The manufacturers maintain that, as a result, they neither understood the program nor had any vision of future orders.

On the last day of the inspection, the Iraqis provided project planning, procurement, and design information that may permit more detailed evaluation of this process and the verification of Iraqi statements about total production of separators.

Research and Development Facilities and Accomplishments

8. According to Dr. Jaffar, work began on the EMIS project at Tuwaitha in 1982 as a result of the decision to abandon the reactor program after the Osirak bombing.

Separator development at Tuwaitha progressed through the construction and operation of several separators of different designs. In the first stage, a 400-mm (radius of beam curvature) isotope separator was built. It achieved a 1-mA current and permitted the testing of insulator and liner concepts.

In the second stage, a 500-mm and three 1000-mm separators were built and operated at Tuwaitha. These separators were used to test larger ion sources, multiple ion sources and a hexagonal liner design; control system and collector concepts were tested as well. Following on those efforts, the quad source of the 1200-mm system was designed for installation at Tarmiya, the magnet for the 600-mm Tarmiya machine was designed and built, and the double ion source and collector system for that separator were designed.

In parallel with separator development in Building 80 at Tuwaitha, chemical process development and operational support work was performed in Building 85; the process chemistry for converting $UO_2$ to $UCl_4$ was tested and the design criteria for the Al Jezira facility (i.e. the Mosul Production Facility) determined. The steps for recovering uranium from the separator packets as $UO_3$ (and from the separator liners as $UO_4$) were developed as well. Until the Al Jezira $UCl_4$ production plant became operational, the preparation of feedstock for the Tarmiya testing operation was also performed at Tuwaitha.

As the Tarmiya facility became available, experienced operating and engineering staff were shifted from Tuwaitha. At the time of the 16/17 January bombing, the new staff at Tuwaitha had reportedly acquired considerable experience. The highest enrichments achieved were declared to have been 17% for gram quantities and 45% for milligram quantities. Progress reports submitted to the inspection team by the Iraqis and claimed to have been prepared during the actual operation of the Tuwaitha and Tarmiya facilities may -- if authenticated -- provide verification of the production. On the basis of very generous assumptions about the operation of prototype equipment, it was previously calculated that the Tuwaitha facility could have produced a maximum of 3 kg of enriched material during its probable operational period. Given the types of experiment which - it now appears - were carried out in Building 80, a much lower number is more probable.

Ministry of Industry Production Facilities

9. The team visited several mechanical production facilities declared during the third inspection, used for the indigenous fabrication of the magnets, vacuum chambers, ion sources and collector components of the separators. Among these facilities were the State Establishment for Heavy Engineering Equipment (SEHEE), Al Dura, Badr General Establishment, and three facilities grouped together as the Auqba Bin Nafi Establishment (Al Radwan, Al Ameer and Al Amin). Their capabilities before the Gulf conflict and their likely production rates are consistent with the Iraqi statements about amounts of EMIS equipment produced. However, until the Iraqi authorities comply with the repeated requests for the submission of production records, an independent check of this conclusion will not be possible.

The most impressive equipment were the 6m-diameter vertical turning machines at Al Radwan and Al Ameer that were used to produce the pole pieces for the Tarmiya separators.

The production of large and small separator components consumed 70% of the effort of Al Radwan and Al Ameer in the last year before the war. These facilities were nearly destroyed during the war and are at least 12-18 months away from being operable.

The production and integration of electrical systems remain less well understood than those of the mechanical systems. The electric equipment facility at Zaafaraniyah Dijlah was capable of producing the necessary power supplies, but had been thoroughly sanitized by the time of the second inspection. The control computers, fibre optic links, and Computer Assisted Measurement and Control (CAMAC) equipment necessary for system integration and operation are not controlled items and are widely available. The Iraqis have submitted schematic designs and procurement records that should clarify the design and procurement sequences involved in building this equipment.

Feed Material Plants

10. Feed material for Tuwaitha operations and for the initial start-up of Tarmiya was provided by the chemical engineering laboratory at Tuwaitha (Building 85). Support for full-scale production work at Tarmiya - and potentially Ash Sharqat - was to come from the new feedstock plant at Al Jezira, near Mosul, where there were two separate plants - one for $UO_2$ production and one for $UCl_4$, the latter having two parallel lines.

According to the Iraqi authorities, the $UO_2$ plant was designed to produce 500 kg/day, began cold tests and precommissioning tests in July 1989 and began trial operation in November 1989; by the time of its destruction, in January 1991, it had produced, according to the Iraqi authorities, 96 t of $UO_2$, which had been transferred to the custody of the Ministry of Industry.

The $UCl_4$ plant's parallel lines were each designed to produce 150 kg/line/day. One line began precommissioning tests in February 1990 and continued in unstable trial operation until November 1990. The plant was declared by Iraq to have produced 1.2 t of $UCl_4$, which was released to the Ministry of Industry. The bombing and Iraq's subsequent salvaging efforts caused substantial destruction of the $UCl_4$ plant.

According to the Iraqi authorities, two additional processes were to have been added to the plant. A line had been designed in case the 1.5 kg cylindrical slugs of $UCl_4$ used in the separator ion sources. Dr. Jaffar disclosed that Al Jezira would have been the site for $UF_6$ production for the centrifuge program as well. It was claimed, however, that no detailed design work had been done by the time of the war.

Process Equipment and Facilities

11. The Tarmiya site was also revisited by this team. Because of the fact that further disclosures had been made by the Iraqi EMIS project personnel, a very thorough analysis of the whole site was made. The design details of the 1200 mm separators are now understood. Thanks to this design understanding - coupled with information obtained during discussions with the Iraqi operating staff, the results of isotopic analyses to be carried out in the next few weeks on samples taken from the few recovered ion sources, and submitted progress reports - it should soon be possible to verify the accuracy of the Iraqi-declared separative work in total.

The Iraqis had eight 1200mm separators in operation in Building 33 at Tarmiya, the declared initial operating dates ranged from 23 February 1990 to 10 September 1990, and this declared average availability was 15%. There was a single spare quad ion source for the eight separators. As the chemical facilities on-site had not yet been commissioned, the graphite collectors were returned to Tuwaitha for uranium recovery and the liners and sources were washed down for $UCl_4$ recovery in a temporary facility in building 54 at Tarmiya.

Each of the eight separators required a loading of 6 kg of $UCl_4$ at the start of each run and, according to Iraqi operating staff, achieved production operation on only 30% of the system vacuum cycles. In the light of discussions with the Iraqi authorities, the detailed process by which the separators were installed, debugged and improved seems credible.

A second line of 17 separators was being installed in Building 33 at Tarmiya at the time of the bombing. These separators were to incorporate improvements in liner design. Although the Iraqis were not specific on this point, it appears that the magnets, return iron, vacuum systems and power supplies were being installed at the time of the bombing. Ion sources and collectors were still in production according to Iraqi statements.

Building 245, designed to house the 600 mm separators, was incomplete in January 1991. A detailed description of how the twenty 600 mm separators were to be installed and a sketch of the design of the magnet system for these separators were provided. Dr. Jaffar subsequently released the design drawings of the dual ion source and collector systems to be used in their initial operation. Dr. Jaffar also indicated that a subsequent upgrade to four-source systems was considered possible. Six prototype magnets and vacuum chambers had been fabricated for the 600 mm system and six ion sources and collectors were being fabricated when the programme stopped.

Two chemical process buildings at Tarmiya were designed for the recovery of $UCl_4$ as $UO_4$ from liners. Building 57 was to service the 1200mm separators and Building 225 the 600 mm separators. The design batch size for Building 57 was $10m^3$ of $HNO_3$ wash solution per day, corresponding to the output of eight 1200 mm per day. The design batch size for Building 225 was $4m^3$ of solution per day, representing approximately the same capacity for the smaller separators. It should be noted that the design of process piping and vessels for Building 225 explicitly included criticality evaluations, indicating an intention to produce and handle HEU. Important in the discussion of the throughput criteria for these buildings was the admission that each was designed to handle the ultimate site capability and that a duplicate source and collector system would eventually be fabricated for each separator. That step, plus the installation of modified liners designed for quicker removal, raises the design availability for the separators from the Iraqi claim of 55%. The distribution of recovery functions between two buildings reinforces the conclusion that the production of HEU was a major design goal of the facility.

Building 46 at Tarmiya was designed for the batch recovery of uranium as $UO_3$ from collector pockets of the separators; enriched and depleted uranium from 1200 mm and 600 mm separators respectively would be recovered in four separate halls. The facility was sized for the ultimate site capacity.

The team carried out an inspection of Building 271, the separator support building. In this building, ion source and collector stores were kept, source and collector refurbishment was performed, vacuum checks and high-voltage tests were performed, and a universal co-ordinate machine (UCM) was used to verify the proper alignment of source and collector components in three dimensions. The thoroughness and scale of the industrialization of the Tarmiya site are evident from the use of bar coding and from the computerization of source and collector part ordering and inventory maintenance that were described during the inspection of this building.

The Tarmiya facility and its equipment were effectively destroyed by bombing and during subsequent dismantling and deception operations carried out by the Iraqis. The replica facility at Ash Sharqat was equally damaged.

12. It is possible - but by no means certain - that full production operation at Tarmiya might not have been achieved for another 18-36 months. The Iraqis claimed major design and operational failures at the Al Jezira facility that, if not promptly corrected, could have delayed adequate feedstock supply. They also claimed difficulties in the supply of graphite for collector pockets. Finally, there may have been human resource problems associated with these large facilities. What is clear from the quality and dedication of the people involved in this effort is that the problems would, at most, only have caused temporary delays.

In summary, the EMIS system being brought on line at Tarmiya alone could have produced 15 kg of HEU per annum (at 55% availability), and there was considerable upgrade potential that it is both prudent and reasonable to assume the Iraqis would have exploited.

Verification and Reconciliation

13. The Iraqis are still engaged in the recovery from desert disposal sites of the materials removed for concealment and destruction. They themselves have expressed concern about the difficulty of verifying their statements to the IAEA and the Special Commission. With the exception of major components such as magnets, coils, and backplates of vacuum boxes, verification of their statements remains incomplete. Four ion source assemblies have been recovered, but no significant fraction of the collector assemblies has been found. Some critical production equipment has been located, but the location of the coil winders has not yet been divulged. Given the nature of the dispersal and destruction operations which were carried out under the direction of the Iraqi military authorities, verification on the basis of production, acceptance and operating records may be necessary - but there will be a considerable element of uncertainty. At present, a data set consistent with the Iraqi declarations is available, but it has not been fully verified.

14. Major components of the EMIS system, such as magnets, coils and vacuum boxes, can be cut apart under supervision and released for salvage. Much of the multi-use equipment from Tarmiya and Ash Sharqat, such as transformers, switchgear, air-handling equipment and chillers, has already been removed from the site by the Iraqi authorities - for use, it is said, elsewhere in the Iraqi economy. What, if anything, remains can be either destroyed or released. Dies and coil-winding machines were used to produce unique process equipment, and their destruction will be required. The use of vertical turning machines capable of producing items larger than 3 m in diameter should be closely monitored.

The chemical production site at Al Jezira has been destroyed. Re-use of this site and of the sites at Tarmiya and Ash Sharqat should be for declared purposes and subject to inspection. The Iraqis have mentioned their intention to rebuild the Tuwaitha site for use in a regional, open research program. If this is done, close monitoring would be required.

**The Gas Centrifuge Enrichment Project**

15. During the third IAEA inspection, the Iraqis had declared that they had been conducting a gas centrifuge enrichment project but that it was second in priority to the EMIS project. They supplied the third inspection team with some centrifuge operating test data, but only on single-centrifuge machines. In addition, at the end of the third inspection visit they produced a small number of centrifuge components for inspection.

A priority task of the fourth inspection team was to obtain a much more comprehensive picture of the Iraqi gas centrifuge programme, including details of the overall plan and direction of the programme.

Research and Development

16. During visits by the fourth team to Tuwaitha and other establishments and at two seminars, Iraq reiterated their achievements with single-machine testing. They claimed to have carried out early testing during 1987 on an oil-type centrifuge (Model 1), an aluminum cylinder three inches in diameter employing oil-lubricated bearings. The tests were terminated when Iraq's magnetic/pivot bearing centrifuge (Model 2) became available.

This design is based on the Zippe Type Centrifuge. Two types of rotor were planned: an all-maraging-steel rotor with caps and baffles electron-beam-welded into place and a carbon-composite rotor cylinder with maraging steel caps and baffles held in place with epoxy resin. The main drawings of the rotating components and of the central feed and extraction pipes were supplied.

Iraq reiterated that only single-machine tests had been carried out in the mid-1988 to late 1990 period . A carbon rotor design speed of 60,000 RPM (456 m/sec wall speed) was achieved with two rotors, one in a mechanical test stand and one with UF6 gas in the process test stand. A Separative Work Output per machine of about 1.9 SWU/year was obtained, but with optimization they were expecting to achieve a 2.7 SWU/year output.

Details were given of the layout of the laboratory in Building 63 at Tuwaitha in which these experiments were declared to have been conducted, together with a description of the problems encountered. These problems suggest that the Iraqis' scientific understanding was still limited, with test work only just begun. The Iraqis also explained that, owing to limited $UF_6$ availability [a claim that contradicts repeated statements by Dr. Jaffar and others that they had no problem in meeting their $UF_6$ requirements], after the completion of a test run, including the mass-spectrometer analysis of product and tails concentration, they mixed the product and tails together to recreate the natural $UF_6$ feed material needed to continue the tests.

Gas Centrifuge Component Manufacture

17. The Iraqis restated that they had made the vacuum housings, the molecular pumps, the ball/pivot and numerous small components themselves at Badr and the State Enterprise for Heavy Equipment Engineering (SEHEE). These two companies had also joined together to build a factory capable of making all the components for the maraging steel (Model 2) centrifuge under the code name Al Furat Project. However, attempts to produce maraging steel cylinders of adequate quality by flow-forming were stated to have been unsuccessful. It was stated that a total of 25 pieces of 350 Grade maraging steel had been obtained (source unidentified). Of these, 19 were machined into preforms at the Nasser Engineering Establishment and the other six by a foreign company (again unidentified). Out of all these, only nine achieved the required tolerance and none was considered good enough for rotor assembly. Quite separately, ten carbon fiber cylinders had been procured from abroad (source unidentified); the two test centrifuges had been constructed from them.

The team prepared a list of the materials and items that are classed as sensitive, or essential, for centrifuge enrichment. Iraq was requested to indicate which items had been acquired abroad, the years of acquisition and the companies that had produced them. On the last day of the inspection Iraq presented its reply. Follow-up actions have been identified on the basis of this reply. Iraq did not meet the requirement of the fourth team that the sources of procurement be identified; in fact, it provided essentially useless information on this point.

The Al Furat Project

18. The Al Furat Project was at the construction stage at a location close to the Badr Engineering Complex, An Walid. The location was declared to have been the planned site for the serial production of gas centrifuges of a maraging steel design. The Iraqis stated that, in a small building designated 803, they had, prior to the outbreak of hostilities, flow-turned the maraging steel tubes and machined the vacuum casings and molecular pumps mentioned earlier. All equipment had been removed prior to the inspection.

The overall project objective was stated to have been to complete the civil construction and machine tool installation by mid-1991. However, all work was halted in August 1990. The Iraqi authorities declared that they had by then procured a number of manufacturing equipment essential to the program.

The machine tools at Badr and SEHEE had been dispersed around 25 July 1991 in an effort to hide them and protect them from possible air attacks. The team saw many such machines stored outdoors or in dirty warehouses. The machines were said to be unused for the most part.

Two indicators suggested otherwise: control consoles with hour meters all showed usage times greater than 100 hours, and many machines had chips caught in various places - in some cases despite cleaning. The machines were said to have been originally intended for use at the Al Furat plant.

Manufacturer's identification data and serial numbers had been defaced or cut off of all the higher-quality equipment. The Iraqis were unwilling to provide procurement data and to specify even the make of the machines.

The Al Furat site was to consist basically of four main buildings, two of them new:

- Building 800 was to be the workshop in which the machines were to be installed to manufacture caps and baffles. The machines were to be supplemented by the machine tools for the manufacture of the vacuum housings, molecular pumps, damper components, and other minor components. The building was divided into two temperature-controlled areas.

- The smaller Building 803 was to be converted into an incoming material store and preparation area.

- Building 802 was to be the flow-forming workshop for the manufacture of maraging steel tubes and for cleaning, galvanizing, painting and inspecting components as necessary.

- Building 801 was to be the rotor assembly and spin testing workshop, possibly with UF6 testing.

The two main buildings (800 and 802) were large, measuring some 100m by 80m each. Clean-room technology of a very advanced design was incorporated into the project and was said by the Iraqis to be their first attempt at building to such strict design specifications.

Although the Iraqis claimed the target output in the first year of operation to be 200 machines from a single shift, it was concluded by the inspection team that the eventual workshop capability would have been far greater – easily 600 machines/year from the equipment already available for this site.

The Iraqi authorities stated that in total the investment at the site would have been 11 million Iraqi dinars for construction and services, $30 million for imported equipment and materials for the buildings and services and, finally, $4.5 million for imported machine tools. It is impossible to verify local construction costs or to accurately assess claimed foreign procurement costs as long as the Iraqi authorities refuse to provide procurement records. The inspection team, having been denied such records, was of the general view that Iraq was understating the cost of this facility.

Detailed drawings of the complex were handed over to the inspection team.

Overall Project Plan

19. The Iraqis provided the inspection team with an overall project plan showing key dates. The highlights of the plan were:

| | |
|---|---|
| Mid 87 - Late 89 | Trials on Model I Centrifuge |
| Mid 88 - Mid 91 | Trials on Model 2 Centrifuge |
| Late 89 - Mid 91 | Construct Centrifuge Production Facility |
| Mid 91 - End 91 | Trial Operation of the Production Facility |
| Early 91 - End 92 | Design and Construct 100-Machine Cascade |
| End 92 - Mid 93 | Install Centrifuges and Pipework |
| Mid 93 | Commence Operation of 100-Machine Cascade |
| Mid 92 - Mid 95 | Design and Construct 500-Machine Cascade |
| Early 95 - End 95 | Install Centrifuges and Pipework |
| Early 96 | Commence Operation of 500-Machine Cascade |

After repeated questions, the Iraqi authorities identified the probable location of the 100-machine cascade as Building BOI at the Al Furat Centrifuge Production Facility.

Cascade Design

20. Cascade calculations had commenced for both a 36-centrifuge and a 102-centrifuge cascade, the aim being to enrich from natural uranium to 3.0% while stripping to 0.35%. These calculations, or at least the curves presented, indicate that the Iraqi scientists were still at an early stage of understanding.

Uranium Feed Preparation for Centrifuges

21. Information supplied by the Iraqis indicates that UF-4 production was initially a wet process. This was replaced by a gas phase system, based on fluorination of $UO_2$ in a rotating tube furnace with Freon 12.

Initially the team was told that $UF_6$ production was a laboratory scale batch tube furnace process using 2.5 times excess of $F_2$. Later it was told that the process was one with three furnaces and cold traps in series. This was said to be 100% efficient in fluorine, leaving an excess of $UF_4$. Iraqi scientists also said that they had developed their own fluorine production cells.

Technical Summation

22. The R & D test programme and cascade design as declared were at an early stage. Nevertheless, the Iraqi authorities were confident enough to press ahead with the construction of a large centrifuge production facility that was designed to a very high standard. Even though the only successful centrifuge trials declared to the inspection team had been carried out with carbon fibre overwrap cylinders, the Al Furat complex was being designed for maraging steel cylinder production - a technology which the Iraqis declared not to have mastered (see para.16). There was no evidence of any attempt to procure or put to work a carbon fibre rotor production line. This inconsistency has to be clarified.

The Iraqi authorities appeared very confident that they could circumvent export controls and obtain adequate quantities of 350 Grade maraging steel to enable them to manufacture all-maraging-steel rotors. The design of caps and baffles - and indeed of the centrifuge overall - leads to the conclusion that substantial help has been given by a person, or persons, with knowledge of an early Western-type centrifuge.

If used in cascade, between 1600 and 2000 centrifuges would be capable of producing 25kg/year of HEU enriched to 90% in uranium-235.

The conclusion reached on the basis of the equipment and information declared by Iraq and the inspections carried out by the team is that unless there is still deception of an inordinate magnitude taking place, the centrifuge enrichment programme was, at the time of the commencement of hostilities, second in priority to the EMIS programme. Also, the team is reasonably convinced that the centrifuge enrichment programme was receiving at least periodic -- and quite probably continuing - assistance from non-Iraqi sources. This assistance went beyond the supply of equipment and materials -- although this was substantial -- and very probably included continuing technical advice.

R & D activities for the centrifuge programme appear to have started later than those for the EMIS programme, but with assistance from abroad with both design and procurement -- - which, in the team's opinion, Iraq certainly received -- and with a fairly large amount of skilled manpower and substantial financial resources being made available the intent was obvious. The programme was set upon a course to produce substantial numbers of centrifuges. The nature of the economics of this effort makes it impossible to draw any other conclusion than that the effort was for non-peaceful purposes. The programme would have reached its objectives with time. The plans set for the mid-1990s would most probably have been achieved once the capability to flow-turn and weld maraging steel had been acquired. While the damage incurred has set the programme back 2 to 3 years, the main know-how is still there.

**Weaponization Activities**

23. The fourth inspection team visited a number of facilities that had been identified, either through Special Commission designation or because of their general characteristics, as possible sites for nuclear weaponization activities.[1/] Among the items shown and the information provided to it, the team found no direct evidence of an on-going weaponization programme. Dr. Jaffar stated that there had been no political decision by the Government of Iraq to proceed with nuclear explosive design and production and that any design activities that had occurred had been only individual exercises by interested scientists.

Whatever the intentions of the Government of Iraq, the team saw remarkable capabilities in relevant technologies -- much, however, in a state of only partial completeness.

There were significant inconsistencies and a lack of candor in the replies of individual facility managers. This increases the concern about the end-use of the technologies being developed, but by itself it is inconclusive.

One of the most visible weaponization activities is high explosive testing. The most suitable facility for this activity which came to the inspection team's attention was the firing bunker -- now heavily damaged - belonging to the Hatheen Establishment at Al Musayyib, near the Al Atheer materials research center. The bunker appears to have been unfinished at the time of the Gulf hostilities, although it has clearly been used a few times for the crude testing of conventional explosives. It is capable of supporting significant physics experiments critical to nuclear weapons development, although no instrumentation of significance was seen. Some construction work is under way at this site despite the damage, and this suggests that such a facility has very high priority. Some development work could have been done at a less sophisticated site, but the team has not found any evidence of this.

Iraqi's uranium metallurgy technology is sophisticated and adequate for a weapons programme. A uranium metal reduction, casting and machining capability at Al Tuwaitha was developed - ostensibly - for an armor penetrator programme. The Al Atheer materials research center has all the capabilities necessary for applying the experience already gained in uranium metallurgy to a nuclear weapons programme if a decision to proceed in such a direction were to be made.

Up until the last day of the inspection, Iraq's high explosive production capability was claimed to be limited to RDX and melt-cast technologies, which are adequate for - but inconsistent with - an optimized nuclear weapon design; the team found no open relationship between the high explosive industry and the IAEC. Late on the last day of the inspection, the team was given the surprising information that "hundreds of tonnes of HMX" had been imported by Iraq and that the Iraqis had considerable experience in casting such material. This raised new questions concerning Iraq's capabilities and facilities and the credibility of previous Iraqi statements which -- because of the manner and timing of the release of the information by Iraq -- it was impossible to pursue adequately.

The team observed the fabrication of exploding bridge wire (EBW) detonators at Al Qa Qaa. Plausible, alternative explanations were given for the Iraqi interest in purchasing and using fire set components. Two experts at Al Qa Qaa have designed and tried to acquire components for firing sets for multi-EBW systems to be used in rocket motor stage separation, with 0.5 microsecond simultaneity. The testing and instrumentation reviewed by the team were crude.

In general, the team did not see instrumentation, diagnostics or experimental set-ups at vacant, damaged or partially finished facilities. This makes it very difficult to assess past performance or intent. What the team saw in the areas of quality control and diagnostics tended to be crude, go/no-go approaches. In response to specific queries, Iraq has now acknowledged the procurement of certain dual-use diagnostic instruments of potential relevance for weaponization.

Initiator science - including Po-210, Be, and deuterium-tritium reactions - was absent in what the team was able to observe. Dr. Jaffar acknowledged that Iraq has produced Po-210 in small quantities for steady-state neutron sources.

With only a very few exceptions, the people met on the sites were technicians, usually ill-equipped to answer questions. Most answers were vague and limited. In sharp contrast, the meetings with Dr. Jaffar were more productive because he had the authority to discuss sensitive subjects.

In general, Al Atheer and its companion facilities at Hatheen and Al Mutayyib constitute a complete and sufficient potential nuclear weapons laboratory and production facility within one common fence line. This combined facility is so big and so well equipped that it can clearly do much more than the limited non-weapons activities that the Iraqis claim as its purpose. It is certainly a top candidate for future monitoring.

**Al Jesira Facility (Mosul Production Facility)**

24. The Al-Jesira Facility (also known as the Mosul Production Facility) was first inspected, on the basis of a Special Commission designation, by the third inspection team. During that initial inspection, the facility -- not previously declared by the Iraqi authorities -- was stated to be a plant for the production of $UO_2$ and $UCl_4$. After the initial inspection, a number of

questions remained open, including questions about precise material flows into and from the facility and whether $UF_6$ was also produced there. Also, in their declaration of 27 July 1991 the Iraqis had stated that waste from this facility had contained 10 tonnes of uranium which had been moved to a nearby location. In an attempt to clarify these matters, it was decided to conduct an additional inspection of this facility; this inspection took place on 5-6 August 1991.

$UO_2$ Production Plant

25. Commissioning of the $UO_2$ plant was declared by the Iraqi authorities to have taken place in July 1989, full operation beginning in November 1989. The design capacity of the plant was declared to have been 500 kg of $UO_2$/day. It was further declared, however, that the plant was seldom able to operate at this rate and was only reaching operational stability at the time of the attack. The 10 tonnes of uranium that went to the liquid waste tanks (see para. 24) were cited as indicative of the problems being encountered.

Although the plant utilities building was heavily damaged, all services were identified. It was felt by the inspection team that they were reasonable for the plant as declared. The receipt and storage area of the plant had been totally removed, graded and covered with gravel by the Iraqis. The process area was collapsed in such a manner that it was clear that the bombing had been only partially responsible - the largest amount of damage being the result of post-attack deception efforts by the Iraqis themselves. The entire plant had been covered by approximately $1m^2$ x 5cm sheets of styrofoam and this in turn covered with dirt. Gravel had been spread thickly around the entire plant, making sampling almost impossible. The general size of the plant seemed reasonable for its declared purpose.

$UCl_4$ Production Plant

Commissioning of the $UCl_4$ plant was said to have been in April 1990. Operational problems were said to have persisted from precommissioning, in February 1990 through to shutdown, in November 1990. It was claimed that actual operations lasted altogether only about two months and that during this period 1.2 tonne of $UCl_4$ was produced and shipped to the Ministry of Industry.

The design capacity of the $UCl_4$ plant was said to be 150 kg $UCl_4$/day/line. There were two lines, but only one was said to have been operational. Corrosion problems were declared to have been the major reason for production problems. In addition, volatility problems in the furnaces and problems with the chillers were said to have hindered operations.

The operators stated that the plant was the "only industrial $UCl_4$ supplier in Iraq"; they had no knowledge of who would use the $UC1_4$, they did not know what processes would require the $UC1_4$, they had never been visited by any staff of the IAEC, and they had no plans to expand production to include other uranium compounds. All of these statements by the operators were subsequently found to be false. It was declared that all $UCl_4$ was produced for and sent to the Ministry of Industry in Baghdad. However, all computer records of production, procurements and shipments were declared to have been stored, without backups, on a single personal computer that was destroyed in the bombing.

Relatively little damage was done by the bombing to the $UCl_4$ production plant; the purification (sublimation) area and the utilities suffered most. In the production area, the greatest damage was the result of post-bombing deception activities of the Iraqis themselves. The reception, laboratory and process areas had been cleared of all equipment, and the floors and lower walls had been painted; dirt had been thrown on top of the wet paint. The control room and offices suffered little damage, but all equipment and records had been removed. The computer was said to have been housed in a

different building and to have been destroyed. If there was indeed no on-line data acquisition at this plant, there would have had to be hard copies of the data. The team found the residues of several paper "camp fires" outside the building - an indication of pre-inspection document destruction. In subsequent discussions, the Iraqi authorities admitted that plans called for the on-site production of EMIS source slugs and a $UF_6$ production line to support the centrifuge programme.

Wastes from the $UO_2$ Plant

27. As earlier described, the Iraqis declared that wastes from the $UO_2$ plant contained 10 tonne [later stated to be 13 tonne] of uranium as a result of equipment design problems and operational errors; the wastes had been stored in two evaporative tanks. When the bombing started, the Iraqi authorities feared that these open tanks would be hit and cause an environmental problem. They therefore decided to transfer the solution (approximately 2500 $m^3$) by truck to a 5000-$m^3$ petroleum storage tank about 30 km from Al Jesira. This storage tank contained an unknown volume of kerosene. Although repeated attempts were made to gain a coherent explanation as to why the Iraqis felt the thick-walled, open evaporative tanks were more hazardous than an oil tank farm as a storage location, none was forthcoming. The most probable explanation - and the one that fits the other large-scale deception efforts carried out at this plant - is that the wastes were moved in order to avoid detection of the real purpose of the plant within Iraq's undeclared uranium enrichment programme.

28. During the inspection, the waste tanks at Al Jesira were found to be about two-thirds full of water said to be for fire protection. There was evidence of solution spillage from the two evaporative tanks. Extensive pouring of new concrete around these tanks had occurred, so that sampling was fruitless. The petroleum storage tank posed sampling problems: the external valve intended for use in sampling could not be opened -- nor could it have been closed if forced open -- and internal baffels in the tank prevented deep sampling from the top.

In any case, the solution was inhomogenous and no capability existed for homogenizing it. The sample finally taken consisted primarily of kerosene and was not representative of the declared 10 tonne of uranium in the waste.

**Nuclear-Material-Related Issues arising during the Fourth Inspection**

29. The first IAEA inspection Mission carried out pursuant to Security Council resolution 687 took place from 15 to 21 May 1991, the primary objective being to verify the accuracy and completeness of the declarations made by Iraq on 18 and 27 April 1991. The declarations did not mention previously exempted nuclear material, which included one irradiated fuel assembly of the IRT-type containing 1200 g of 10%-enriched uranium (initial values); exemption had been approved by the Agency on 11 May 1988.

At the insistence of the first inspection team, the Iraqis presented the previously exempted material, which - as a result of chemical reprocessing activities that they had carried out with the material - consisted of the chemically recovered uranium together with 2.3 g of plutonium separated from the irradiated fuel assembly and then purified. More importantly, the Iraqis declared that the exempted material had been subjected to "fuel reprocessing experiments". Exemption had been granted under Article 37 of INFCIRC/172 (the agreement between Iraq and the IAEA for the application of safeguards in connection with NPT), which limits the quantity of nuclear material that can be exempted from safeguards in a State

On 27 July 1991 Iraq submitted to the fourth inspection team a list of nuclear material which included material not previously declared (Appendix 1); there were 20 separate items related to the Iraqi nuclear programme. The list was discussed with the Iraqis on 1 August.

Since the 7 July declaration it was apparent that Iraq had embarked on a clandestine programme to produce natural uranium fuel elements from undeclared nuclear material ($UO_2$) in the Experimental Reactor Fuel Fabrication Laboratory (ERFFL), to irradiate this fuel in the IRT-5000 reactor and subsequently to chemically process the irradiated fuel in the Radiochemical Laboratory, to which safeguard inspectors had no access. On 1 August the inspection team raised additional questions which were submitted to the Iraqis in writing on 2 August. A written reply was received on 6 August.

The following details relate to items No. 1, 2, 5, 10, 16 and 17 (see Appendix 1) of the 27 July declaration, which the team believes should be considered in any further assessment of Iraq's conduct in relation to its obligations under INFCIRC/172.

Item No. 1 (uranium metal)

Of the declared 27,000 kg of uranium metal declared on 7 July 1991 to have been imported from Brazil, 1000 kg had been converted to uranium metal for what was stated as use in a heavy bullet production programme.

Item No. 2 (3g of separated plutonium)

This plutonium had been recovered from irradiated natural uranium fuel elements within the framework of what was stated to have been an R&D programme related to "Pu extraction from spent fuel" in order to "to determine operational conditions for the manufacture of ceramic nuclear fuel which can be used in nuclear plants".

It was declared that three fuel elements (very similar to the EK-10 type but containing natural uranium oxide) had been manufactured between 10 December 1988 and 2 February 1989 at the Experimental Reactor Fuel Fabrication Laboratory (ERFFL). These fuel elements were stated to have been irradiated in the IRT-5000 as follows:

- One element: 22 days irradiation over 7 weeks (3 days/week) between February 1989 and April 1989; separated plutonium about 0.5g
- Two elements: 50 days irradiation between September 1989 and January 1990; separated plutonium about 2.2 grams

Irradiation had been performed using two different positions of the beryllium (Be) reflector in the IRT-5000 reactor core. According to available information, the irradiation was not continuous, i.e. the fuel elements could have been temporarily removed from their positions in the beryllium reflector in order to escape detection by safeguard inspectors. The IRT-5000 reactor had been regularly inspected twice a year.

The chemical processing of the three irradiated fuel elements and the purification of the separated plutonium were declared as having been carried out in Al Tuwaitha Building No. 9, the Radiochemical Laboratory (to which the safeguards inspectors had not had access), according to the following schedule:

- One element: between November 1989 and February 1990
- Two elements: between the beginning of February 1990 and July 1990

Item No. 5 (two irradiated fuel cells)

It was clarified in discussions with the Iraqi authorities that the terms "cell" and "element" are equivalent; basically the elements ("cells") are aluminium casings (shrouds) of the EK-10 type into which the zircaloy-cladded pins were loaded. Asked about the facility where the casings were produced, the Iraqis stated that the casings were taken from dummy fuel elements supplied by the USSR. However, the team believes that the manufacture of casings of this type would not have posed a major technical problem for Iraq.

The two elements ("cells") contain 7.9 kg of natural uranium in the form of $UO_2$ pellets, the $UO_2$ powder was stated as having been produced at the Mosul purification, and conversion plant; the uranium was said to have originated at the Al Qa'im facility (phosphate fertilizer complex).

The manufacturing facility for the pins was said to be the ERFFL, production being declared as having taken place in the period between 13 August 1989 and 17 November 1989.

Irradiation of these two elements is said to have been for a total of 37 days in the safeguarded IRT-5000 reactor during the period from mid-September 1990 to the first week of November 1990. At the time of the hostilities, the two elements had not yet been chemically reprocessed as planned. The Iraqis refused to answer repeated requests for the date of the removal of the two elements from the reactor core. They stated that, after removal from the core, the elements were put into a water-filled steel cylinder, placed on a truck prior to the first inspection mission then moved around in order to avoid detection by the first three inspection teams. The fourth team was told that during the first inspection this truck was within the boundaries of the Tuwaitha facility and that it moved as the inspectors moved. Immediately before the fourth team arrived, on 27 July 1991, the elements are said to have been placed at Location B, in an additional storage tank which had not been declared as such to previous teams. This must count as one of the most potentially dangerous deception activities encountered so far by the inspection teams. This information was received only on 6 August 1991. On 8 August 1991 the team visited Location B and found two storage tanks in addition to the previously declared 14 tanks. At the team's request they were both opened. One tank contained the two irradiated elements in a water-filled open steel cylinder. The other tank contained five irradiated beryllium elements from the IRT-5000 core; they were stored in a drum.

The storage tank with the two cells was given the number 15, photographs were taken and it was seals were applied using the procedure previously applied to tanks 1-14.

Item No. 10 (46 natural $UO_2$ experimental fuel rods)

These rods were made of $UO_2$ pellets in zircaloy cladding; production occurred at the ERFFL between 20 November 1990 and 30 December 1990. The total uranium contained is 11,000 g. The rods had not yet been irradiated and are currently stored at the "New Storage".

Item No. 16 (radioactive waste)

The Iraqis stated that this waste originated primarily from the spent fuel reprocessing activities performed in Building No. 9, where the three elements (item 2 above) were reprocessed. The liquid waste (HAW) had been diluted with low-activity waste (LAW) and subjected to concentration before bitumenization in Building No. 35 (Radioactive Waste Section) during the period February 1990 to May 1990.

Item No. 17 ($UCl_4$)

This type of nuclear material was already included in the 7 July 1991 declaration. The material was used in the EMIS programme, i.e. it was suitable for isotopic enrichment and had therefore reached the starting point of safeguards.

/...

30. The 27 July 1991 declaration provided additional information that seems to the team to constitute evidence of Iraq's violations of existing safeguards provisions. However, of more immediate concern was the additional information which was obtained during question/answer sessions with the Iraqis and which relates to their sometimes reckless efforts to deceive safeguards inspectors and the inspection teams.

The team was particularly concerned by the fact that many Iraqi statements were not supported by any source "documentation" - production records of the fuel fabrication plant, nuclear material transfer records, reactor operation records, fuel history cards, etc. The Iraqi authorities claimed that these documents/records had been destroyed, but in the light of various observations (e.g. of empty but unburnt filing cabinets) the team does not consider this to be a credible explanation; moreover, one would have expected that, with a fuctioning national nuclear materials accounting system, the Iraqis would keep duplicates of relevant documents at the IAEC's establishments.

Therefore, the magnitude of Iraq's nuclear fuel manufacturing capability and the declared amount of irradiated and chemically processed irradiated fuel remain subject to a great deal of uncertainty.

Under any circumstances, however, Iraq should be required to provide the IAEA with a complete itemized inventory list of nuclear materials, which should indicate:

- the origins of all nuclear materials in Iraq's possession as of 3 April 1991;
- the places/facilities where the materials were produced or processed;
- their current location.

This would facilitate verifications of the accuracy and completeness of the various Iraqi declarations (18 and 27 April, 7 and 27 July).

**The Iraqi Nuclear Program - A Material Flow Perspective**

31. The attached schematic chart with flow and inventory quantities represents accumulated information to date (19 August 1991). The flows and inventories are based on information acquired from:

1) The November 1990 IAEA inspection report;
2) Safeguards Information Treatment accounting printouts;
3) The 27 April 1991 Iraqi declaration;
4) The 7 July 1991 Iraqi declaration and follow-up reports;
5) The 27 July 1991 Iraqi declaration and follow-up reports; and
6) Discussion, briefing and seminar notes from IAEA inspection missions 3 and 4.

Much of the information on nuclear material provided by the Iraqis has been conflicting or incomplete. An effort has been made in preparing this schematic overview to evaluate the data, to identify areas of consistency and inconsistency, and to identify gaps in the information. Missing or questionable data will require follow-up actions. Further review is also needed by members of the last two inspection teams. Therefore, changes and/or corrections will be made as they prove necessary. The objective in preparing an overview of this type is to provide a framework for organizing and testing the information that is now becoming available. With such a framework it should become easier to detect erroneous data and gaps in our knowledge with regard to where nuclear material flowed in both the open and the clandestine parts of the programme. Following is a material balance summary corresponding to the attached schematic chart. All quantities refer to elemental uranium.

APPENDIX I

In response to the request of the International Inspection Team during the third inspection visit, the table of nuclear material previously mentioned in the letter of the Iraqi Foreign Minister dated 7 July 1991 was rearranged in fulfilment of the promise of the Vice-President of the Iraqi Atomic Energy Commission (IAEC) to the International Inspection Team.

| Ser. No. | Material | Weight | Remarks |
|---|---|---|---|
| 1 | Uranium metal | 1 ton (approx) | |
| 2 | Plutonium ($PuO_2$ & solutions) | 3 g (approx) | |
| 3 | ADU (ammonium di-uranate) & uranium oxides | 50 g (approx)<br>70 g (approx) | Enriched at 10% (remains of the material exempted by Safeguards) |
| 4 | Uranium tetrafluoride | 20 kg (approx) | |
| 5 | Irradiated fuel cell (element) | | Two items |
| 6 | New Berillium cell (element) | | One item |
| 7 | Scrap $UO_4$ | | Eight barrels |
| 8 | $UO_2$ powder | 2.5 tons (approx) | |
| 9 | Ventilation filter containing $UO_4$ | 100 kg | |
| 10 | Natural $UO_2$ fuel rods (experimental) | | 46 rods |
| 11 | ADU (natural uranium) | 220 kg (approx) | |
| 12 | $UO_2 (NO3)_2$ powder (natural uranium) | 400 g (approx) | Imported laboratory samples |
| 13 | U308 natural uranium | 100 kg | |
| 14 | Plutonium | mgs (no figure) | Imported ampules |
| 15 | $UO_4$ in the form of liquid wastes from Al-Gesira laboratory | 10 tons (approx) | |
| 16 | Radioactive wastes in the form of concrete containers (58 containers) | | Radioactive wastes that do not contain nuclear material |
| 17 | Packages full of $UCl_4$ and plastic containers of $UCl_4$ | 150 kg (approx) | |
| 18 | Liquid wastes of natural uranium | 6 kg (approx) | |
| 19 | U233 | 63 mgs | Imported |
| 20 | Depleted uranium | 2 kg (approx) | Imported |

**Notes**

1. All the above weights are approximate.

2. List of enriched and depleted uranium produced by the separators in Al Tuwaitha site were handed over to the Third Inspection Team on 18 July 1991.

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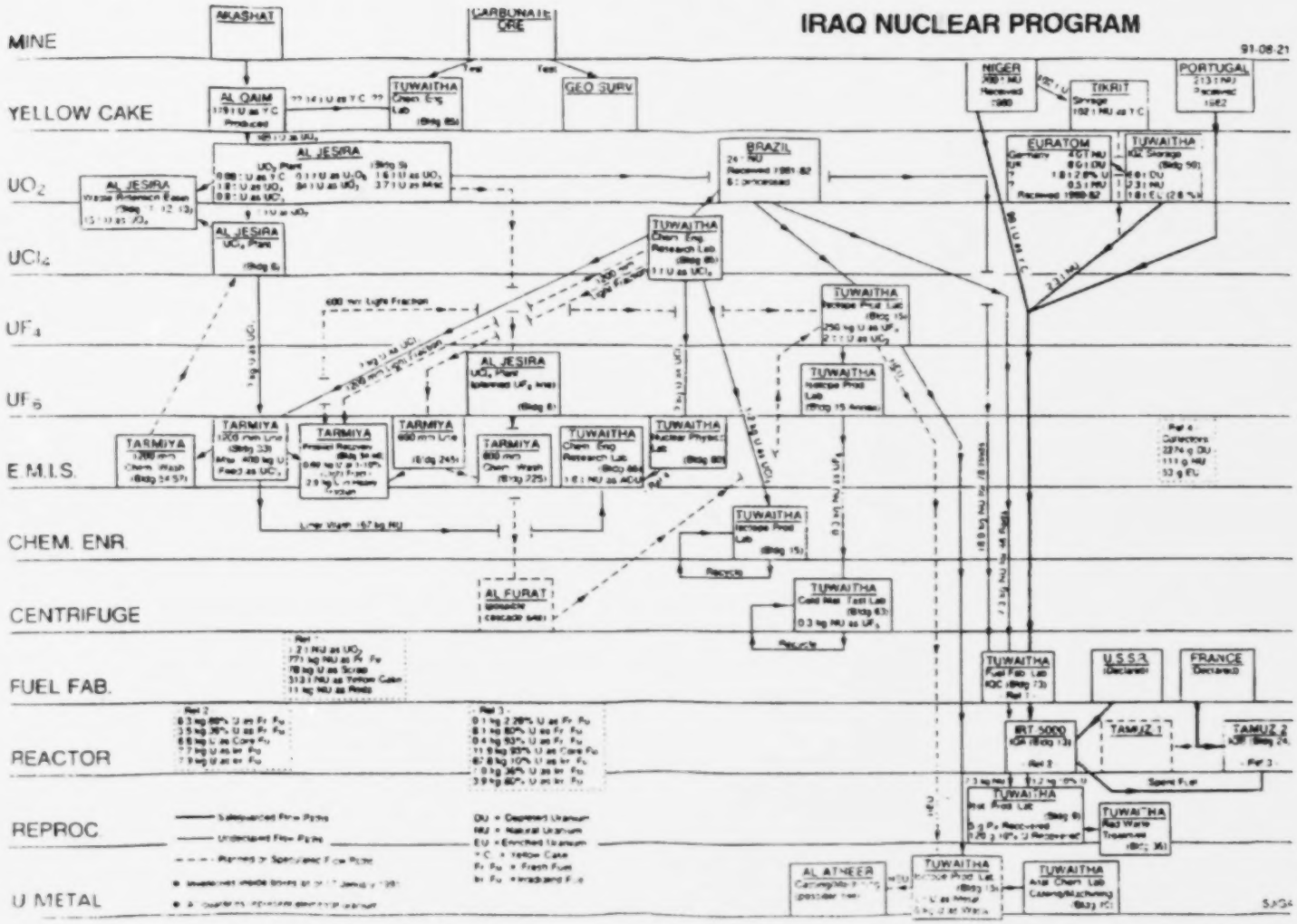
IRAQ NUCLEAR PROGRAM
91-08-21
MINE
YELLOW CAKE
UO2
UCl4
UF4
UF6
E.M.I.S.
CHEM. ENR.
CENTRIFUGE
FUEL FAB.
REACTOR
REPROC.
U METAL
AKASHAT
CARBONATE ORE
AL QAIM
TUWAITHA
GEO SURV
NIGER
TIKRIT
PORTUGAL
AL JESIRA
BRAZIL
EURATOM
TARMIYA
AL FURAT
USSR
FRANCE
IRT 5000
TAMUZ 1
TAMUZ 2
AL ATHEER